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NATIONAL DAM SAFETY PROGRAM. FROELICH LAKE DAM (MO 31443), MISS--ETC(U)
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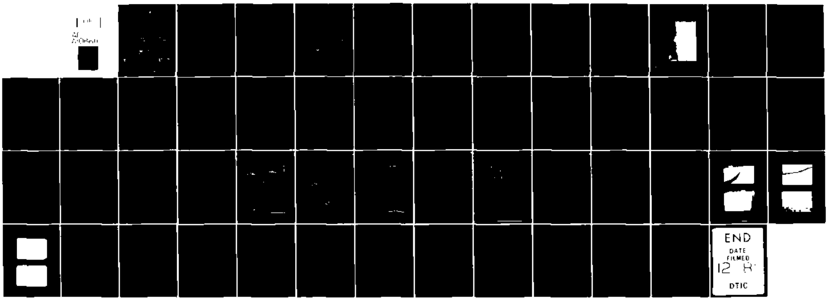

LEVEL II

MISSOURI - KANSAS CITY BASIN

FROELICH LAKE DAM

WARREN COUNTY, MISSOURI

MO 31443

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

OCTOBER 1980

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National Dam Safety Program
Froelich Lake Dam (MO 31443)
Warren County, Missouri

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National Dam Safety Program. Froelich Lake Dam (MO 31443), Missouri - Kansas City Basin, Warren County, Missouri. Phase I Inspection Report.

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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U.S. G.P.O. 1980-665-141/1299

MISSOURI - KANSAS CITY BASIN

FROELICH LAKE DAM

WARREN COUNTY, MISSOURI

MO 31443

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

OCTOBER 1980

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

LMSED-P

SUBJECT: Froelich Lake Dam, MO 31443, Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Froelich Lake Dam (MO 31443):

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

1) Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

2) Overtopping of the dam could result in failure of the dam.

3) Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED — Chief, Engineering Division — 17 NOV 1980 Date

APPROVED BY: SIGNED — Colonel, CE, District Engineer — 17 NOV 1980 Date

FROELICH LAKE DAM

MISSOURI INVENTORY NO. 31443

WARREN COUNTY, MISSOURI

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

HORNER & SHIFRIN, INC.

5200 OAKLAND AVENUE

ST. LOUIS, MISSOURI 63110

FOR

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

CORPS OF ENGINEERS

OCTOBER 1980

HS-8011

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Froelich Lake Dam
State Located:	Missouri
County Located:	Warren
Stream:	Subtributary of Charrette Creek
Date of Inspection:	25 July 1980

The Froelich Lake Dam was visually inspected by engineering personnel of Horner & Shifrin, Inc., Consulting Engineers, St. Louis, Missouri. The purpose of this inspection was to assess the general condition of the dam with respect to safety and, based upon this inspection and available data, determine if the dam poses a hazard to human life or property.

The following summarizes the findings of the visual inspection and the results of certain hydrologic/hydraulic investigations performed under the direction of the inspection team. Based on the visual inspection and the results of the hydrologic/hydraulic investigations, the present general condition of the dam is considered to be somewhat less than satisfactory. The following deficiencies were noticed during the inspection and are considered to have an adverse effect on the overall safety and future operation of the dam:

1. Erosion, apparently from spillway discharges, has created a gulley which varies from about 30 inches in depth along the right abutment, to approximately 12 inches in depth along the toe of the dam. A channel about 24 inches in depth that appeared to be due to erosion by stormwater runoff was present along the left abutment, near the downstream toe of the dam. Loss of embankment material or material adjacent to the embankment by erosion can impair the structural stability of the dam.

2. Erosion of the grass covered upstream face of the dam apparently by wave action and/or fluctuations of the lake surface level has created a near vertical bank up to about 12 inches high at the normal waterline. A grass covered slope is not considered adequate protection to prevent erosion of the embankment by wave action or fluctuations of the lake level.

3. Seepage, as evidenced by small willow trees, soft ground, and standing water was observed near the left abutment at the toe of the dam. Uncontrolled seepage can develop into a piping condition (progressive internal erosion) that could result in falure of the dam.

4. Several small trees up to 2 inches in diameter exist on the downstream face of the dam. A few holes believed to be old animal burrows exist along the upstream face of the dam. Tree roots and animal burrows can provide passageways for seepage that could develop into a piping condition resulting in failure of the dam.

According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for the Froelich Lake Dam, which is classified as small in size and of high hazard potential, is specified to be a minimum of one-half the Probable Maximum Flood (PMF). Considering the fact that a manmade lake, Lake Innsbrook, lies within the possible flood damage zone for this dam, and since failure of the Froelich Lake Dam by overtopping could result in failure of the downstream dam which would endanger the lives of a number of people living within the downstream flood damage zone for the Lake Innsbrook Dam, it is recommended that the spillway for this dam be designed for the PMF. The Probable Maximum Flood (PMF) is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF is ordinarily accepted as the inflow design flood for dams where failure of the structure would increase the danger to human life.

Results of a hydrologic/hydraulic analysis indicated that the spillways (principal plus emergency) are inadequate to pass lake outflow resulting from

a storm of PMF magnitude without overtopping the dam. The spillways are capable of passing lake outflow corresponding to about 14 percent of the PMF and the lake outflow resulting from the 1 percent probability (100-year frequency) flood. According to the St. Louis District, Corps of Engineers, the length of the downstream damage zone, should failure of the dam occur, is estimated to be 1 mile. Accordingly, within the possible damage zone are portions of the Innsbrook Subdivision development including the dam for Lake Innsbrook, which according to the Corps of Engineers, has a high hazard classification.

A review of available data did not disclose that seepage or stability analyses of the dam were performed. This is considered a deficiency and should be rectified.

It is recommended that the Owner take the necessary action without undue delay to correct or control the deficiencies and safety defects reported herein. The provision of additional spillway capacity should be pursued on a high priority basis.

Ralph E. Sauthoff
P. E. Missouri E-19090

Albert B. Becker, Jr.
P. E. Missouri E-9168

OVERVIEW FROELICH LAKE DAM

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

FROELICH LAKE DAM - MO 31443

TABLE OF CONTENTS

LIST OF PLATES

APPENDIX A - INSPECTION PHOTOGRAPHS

APPENDIX B - HYDROLOGIC AND HYDRAULIC ANALYSES

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

FROELICH LAKE DAM - MO 31443

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, directed that a safety inspection of the Froelich Lake Dam be made.

b. Purpose of Inspection. The purpose of this visual inspection was to make an assessment of the general condition of the dam with respect to safety and, based upon available data and this inspection, determine if the dam poses a hazard to human life or property.

c. Evaluation Criteria. This evaluation was performed in accordance with the "Phase I" investigation procedures as prescribed in "Recommended Guidelines for Safety Inspection of Dams", Appendix D to "Report to the Chief of Engineers on the National Program of Inspection of Non-Federal Dams", dated May 1975.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances. The Froelich Lake Dam is an earthfill type embankment rising approximately 35 feet above the natural streambed at the downstream toe of the barrier. The embankment has an upstream slope (above the waterline) of approximately 1v on 3.5h, a crest width of about 14 feet, and a downstream slope on the order of 1v on 2.9h. The length of the dam is approximately 435 feet. A plan and profile of the dam are shown on Plate 3 and a cross-section of the dam is shown on Plate 4. At normal pool elevation, the reservoir impounded by the dam occupies

approximately 6 acres. Available information indicated that the lake does not have a drawdown facility.

The dam has both a principal and emergency spillway. The principal spillway, a culvert consisting of two 15-inch diameter corrugated metal pipes, is located at the right, or north, end of the dam. A profile of the principal spillway is shown on Plate 4. The emergency spillway, a shallow excavated earth section, is also located at the right end of the dam. A cross-section of the emergency spillway is also shown on Plate 4. A crushed stone roadway traverses the length of the dam and crosses the emergency spillway channel near its crest. The outlet channel is common for both spillways. The channel, a section of variable width, is protected by riprap and confined by a small dike to a point approximately 100 feet downstream of the dam centerline. Beyond the dike, the channel follows the intersection of the embankment and the right abutment until it reaches the toe of the dam. The channel continues along the toe of the dam to a point near the left abutment where it joins the original stream channel on which the dam is constructed.

b. Location. The dam is located on an unnamed subtributary of Charrette Creek, about 1.5 miles southwest of the intersection of State Highways F and M and approximately 4 miles south of Wright City, Missouri, as shown on the Regional Vicinity Map, Plate 1. The dam is located in the southeast quarter of Section 5, Township 46 North, Range 1 West, within Warren County.

c. Size Classification. The size classification based on the height of the dam and storage capacity, is categorized as small (per Table 1, Recommended Guidelines for Safety Inspection of Dams).

d. Hazard Classification. The Froelich Lake Dam, according to the St. Louis District, Corps of Engineers, has a high hazard potential, meaning that if the dam should fail, there may be loss of life, serious damage to homes, or extensive damage to agricultural, industrial and commercial facilities, important public utilities, main highways, or railroads. The estimated flood damage zone, should failure of the dam occur, as determined by the St. Louis District, extends one mile downstream of the dam. Within the possible flood damage zone are portions of the Innsbrook Subdivision development including

the dam for Lake Innsbrook, which according to the Corps of Engineers, has a high hazard classification. Those features lying within the downstream damage zone reported by the Corps of Engineers, St. Louis District, were verified by the inspection team.

e. Ownership. The lake and dam are owned by Mrs. Dolores Froelich. Mrs. Froelich's address is Rural Route 1, Box 134AB, Wright City, Missouri, 63390.

f. Purpose of Dam. The dam impounds water for recreational use.

g. Design and Construction History. The Owner did not know when the dam was constructed, but she did recall that the original owner of the dam was Mr. Alex Wolff, and that the contractor who constructed the dam may have been the Mudd Excavating Company. Attempts to locate or contact either Mr. Wolff or the Mudd Excavating Company were unsuccessful. The present Owner purchased the lake and dam in 1971.

h. Normal Operational Procedure. The lake level is unregulated. Lake outflow is governed by the combined capacities of a culvert type spillway consisting of two 15-inch diameter pipes, and an excavated earth type emergency spillway.

1.3 PERTINENT DATA

a. Drainage Area. With the exception of a small subdivision with a few homes located near the eastern boundary of the watershed, and two homes located adjacent to the lake, the area tributary to the lake is for the most part in a native state covered with timber. The watershed above the dam amounts to approximately 51 acres. The watershed area is outlined on Plate 2.

b. Discharge at Damsite.

(1) Estimated known maximum flood at damsite ... 2 cfs* (W.S.Elev. 722.4)
(2) Spillway capacity ... 19 cfs (W.S.Elev. 724.0)

*Based on an estimate of depth of flow at spillway as observed by the Owner.

c. Elevation (Ft. above MSL). The following elevations were determined by survey and are based on the elevation of the lake, assumed to be the normal pool level, as shown on the 1972 Wright City, Missouri, Quadrangle Map, 7.5 Minute Series.

(1) Observed pool ... 721.6

(2) Normal pool ... 722.0

(3) Spillway crest ... 722.0

(4) Maximum experienced pool ... 722.4*

(5) Top of dam ... 724.0 (min.)

(6) Streambed at centerline of dam ... 693± (est.)

(7) Maximum tailwater ... Unknown

(8) Observed tailwater ... None

d. Reservoir.

(1) Length at normal pool (Elev. 722.0) ... 870 ft.

(2) Length at maximum pool (Elev. 724.0) ... 900 ft.

e. Storage.

(1) Normal pool ... 53 ac. ft.

(2) Top of dam (incremental) ... 13 ac. ft.

f. Reservoir Surface.

(1) Normal pool ... 6 acres

(2) Top of dam (incremental) ... 1 acre

g. Dam. The height of the dam is defined to be the overall vertical distance from the lowest point of foundation surface at the downstream toe of the barrier, to the top of the dam.

*Based on an estimate of depth of flow at spillway as observed by the Owner.

(1) Type ... Earthfill

(2) Length ... 435 ft.

(3) Height ... 35 ft.

(4) Top width ... 14 ft.

(5) Side slopes

a. Upstream ... 1v on 3.5h (above waterline)

b. Downstream ... 1v on 2.9h

(6) Cutoff ... Unknown

(7) Slope protection

a. Upstream ... Grass

b. Downstream ... Grass

h. Principal Spillway.

(1) Type ... Uncontrolled, two 15-inch diameter corrugated metal pipes (culvert)

(2) Location ... Right abutment

(3) Crest ... Elevation 722.0

(4) Outlet channel ... Excavated earth, trapezoidal section with riprap protection to a point 90 feet downstream of dam centerline

i. Emergency Spillway.

(1) Type ... Uncontrolled, dish-shaped section, crushed stone surfaced roadway at crest

(2) Location ... Right abutment

(3) Crest ... Elevation 723.9

(4) Outlet Channel ... Excavated earth, trapezoidal section with riprap protection (common with principal spillway outlet channel)

j. Lake Drawdown Facility ... None

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No data relative to the design of the dam are known to exist.

2.2 CONSTRUCTION

As previously stated, the owner of the property at the time the dam was constructed was Mr. Alex Wolff. Mr. Wolff's status is unknown, and no data relating to the construction of the dam are known to exist.

2.3 OPERATION

The lake level is uncontrolled and governed by the crest elevation of the two spillway pipes located at the right abutment. An emergency spillway, with a crest elevation approximately 1.9 feet higher than the crest of the principal spillway and about 0.1 foot lower than the top of the dam at its lowest point, is also located at the right abutment.

No indication was found that the dam has been overtopped. According to Mrs. Dolores Froelich, to her knowledge the dam has never been overtopped, and the highest surface elevation observed occurred in July of 1980, when the lake reached a level estimated to be about 5 inches above normal pool elevation.

2.4 EVALUATION

a. Availability. Engineering data for assessing the design of the dam and spillways were unavailable.

b. Adequacy. No data available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the Froelich Lake Dam was made by Horner & Shifrin engineering personnel, T. K. Deddens, Geological Engineer, R. E. Sauthoff, Civil Engineer, and A. B. Becker, Jr., Civil and Soils Engineer, on 25 July 1980. An examination of the dam area was also made by an engineering geologist, Jerry D. Higgins, Ph.D., a consultant retained by Horner & Shifrin for the purpose of assessing the site geology. Also examined at the time of the inspection were the areas and features below the dam within the potential flood damage zone. Photographs of the dam taken at the time of the inspection are included on pages A-1 through A-3 of Appendix A. The locations of the photographs taken during the inspection are indicated on Plate 3.

b. Site Geology. Froelich Lake Dam is located on the southern edge of the Dissected Till Plains section of Central Lowlands Physiographic Province near the northern edge of the Salem Plateau section of the Ozark Plateaus Province. The topography is gently rolling with generally less than 70 feet of relief between the reservoir and the surrounding drainage divides. Unconsolidated surficial deposits are thick at the lake site and no bedrock was noted. Nearby borings indicate the general area to be underlain by up to 100 feet of loess and glacial till covering Ordovician-age sedimentary rock of most probably the Kimmswick formation. The bedrock is dipping slightly to the north. No faults were observed or reported at the site.

The Kimmswick formation is a light gray, coarsely crystalline, medium-bedded to massive limestone. Weathered exposures characteristically appear pitted. The limestones are susceptible to solution weathering and may have solution-enlarged joints and bedding planes, sinkholes, etc. If bedrock is near the surface, these solution features may be a source of reservoir leakage; however, the thick soil deposits at the site tend to minimize the problem of leakage through bedrock.

The unconsolidated surficial materials in the vicinity of the reservoir are composed principally of glacial till, loess, and alluvial deposits. The valley floor is covered by alluvial soils of the Cedargap series. The series consists of a dark grayish-brown silt grading with depth to a very cherty clay. According to the Unified Soil Classification System, the soils are classifed as ML to GC material, are permeable, and may be subject to piping. Soils of the Lindley series cover most of the dam and reservoir area. These are deep, well-drained soils formed on glacial till. The soil typically ranges from a silty clay at the surface, becoming more clayey with depth. Chert fragments are common. The soils are classified as CL-ML to CL materials, exhibit moderately low permeability, and are generally considered favorable for impoundments and embankments. The surrounding uplands are covered with soils of the Hatton series. These are moderaly well-drained clays and silty clays formed from loess. These soils are only present well above the reservoir and dam site.

There appear to be no significant geologic problems at the dam site. No adverse geologic conditions were observed that would be considered conducive to severe reservoir leakage or embankment instability.

c. Dam. The visible portions of the upstream and downstream faces of the dam (see Photos 1 and 2) as well as the dam crest were inspected and, except as noted herein, found to be in sound condition. No surface cracks, sloughing of the embankment slopes, or unusual settlement of the dam crest was noted. Six-inch tall grass covered both the upstream face of the dam and the portion of the crest not overlayed by the crushed stone roadway. No riprap was present along the upstream face of the dam and erosion, apparently by wave action and/or fluctuations of the lake surface level, has created a near vertical bank up to 12 inches high at the normal waterline. Several animal burrows which appeared to be abandoned were noted along the upstream face of the dam above the waterline.

The downstream face of the dam was covered by grass about 3 feet tall with several trees up to 1 inch in diameter also present. Investigation of the surficial soil of the dam indicated it to be a silty lean clay (CL) of low-to-medium plasticity. A channel about 24 inches deep that appared to be

due to erosion by stormwater runoff, was observed along the left abutment, near the downstream toe of the dam. Seepage, as evidenced by small willow trees, soft ground, and standing water, was present near the left abutment at the toe of the dam, however seepage flow was not noticeable.

The visible portions of the two 15-inch diameter corrugated metal spillway pipes (see Photos 3 and 4) as well as the crushed stone roadway which crosses the crest of the emergency spillway, were examined and found to be in satisfactory condition. The spillway outlet channel, which is common to both the principal and emergency spillways, was bounded by dikes and well protected by riprap to a point about 90 feet downstream of the spillway pipes. The riprap appeared to be quarry-run limestone up to about 12 inches in size. Beyond the section of spillway outlet channel protected by riprap, erosion (see Photo 5), apparently by spillway discharges, had created two gullies approximately 30 inches wide and 30 inches deep that extended downstream from the protected area. A gulley up to about 24 inches wide by 24 inches deep was observed along the embankment at the right abutment. An erosion channel up to 12 inches deep by 30 inches wide was also noticed along the toe of the dam (see Photo 6).

d. Appurtenant Structures. There are no appurtenant structures at this dam.

e. Downstream Channel. Near the toe of the dam, the downstream channel is unimproved with dense brush and trees covering the banks. At a point approximately 1,000 feet downstream of the dam, the channel joins the upstream end of Lake Innsbrook.

f. Reservoir. At the time of the inspection, the reservoir was approximately 0.4 feet below normal level, and the water within the lake was clear. Except for the two homes located near the lake, the area about the lake was tree covered with no appreciable erosion apparent. The amount of sediment within the lake could not be determined during the inspection; however, due to the vegetation covering the surrounding area, it is not expected to be significant.

3.2 EVALUATION

The deficiencies observed during the inspection and noted herein, are not considered of significant importance to warrant immediate remedial action.

Based on the relative small difference between the crest of the emergency spillway and the low point of the dam crest, approximately 0.1 foot, determined by survey during the inspection, the effectiveness of the emergency spillway is questionable.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The spillways are uncontrolled. The lake surface level is governed by precipitation runoff, evaporation, seepage, and the combined capacities of the uncontrolled spillways.

4.2 MAINTENANCE OF DAM

According to the Owner, routine maintenance of the dam is performed by Mr. Roger Beste, a neighbor residing adjacent to the south side of the lake. The Owner reported that the grass is not cut and trees are not removed from the downstream face of the dam because of the steep slope. Mr. Beste stated that muskrats seen near the dam are killed. According to Mr. Beste, the two 15-inch diameter spillway pipes for the culvert type spillway were installed in 1979 in order to prevent erosion of the roadway by normal spillway releases.

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

No outlet facilities requiring operation exist at this dam, and there is no reservoir regulation plan.

4.4 DESCRIPTION OF ANY WARNING SYSTEMS IN EFFECT

The inspection did not reveal the existence of a dam failure warning system.

4.5 EVALUATION

It is recommended that maintenance of the dam also include periodic cutting of the grass and the removal of the small trees on the downstream slope of the dam. Provisions should also be made to prevent further erosion of the spillway outlet channel at the right abutment and along the toe of the dam. It is also recommended that a detailed inspection of the dam be instituted on a regular basis by an engineer experienced in the design and construction of dams and that records be kept of all inspections made and remedial measures taken.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data were not available.

b. Experience Data. The drainage area and lake surface area were developed from the 1972 USGS Wright City, Missouri, Quadrangle Map. The proportions and dimensions of the spillways and dam were developed from surveys made during the inspection. Records of rainfall, streamflow, or flood data for the watershed were not available.

Due to the fact that the watershed for this reservoir is small, the lake level was assumed to be at normal pool as a result of antecedent storms prior to occurrence of the PMF and the probabilistic storm.

According to the St. Louis District, Corps of Engineers, the estimated flood damage zone, should failure of the dam occur, extends one mile downstream of the dam. The dam for Lake Innsbrook, which is classified as high hazard by the Corps of Engineers, lies within the potential flood damage zone.

c. Visual Observations.

(1) The dam has both a principal and an emergency spillway. The principal spillway, a culvert type installation consisting of two 15-inch diameter corrugated metal pipes, is located near the right abutment of the dam. The emergency spillway, a dish-shaped section, is also located near the right abutment.

(2) A single outlet channel serves both spillways. The channel initially directs flow away from the dam. However, once beyond the crest section the channel is unconfined and tends to follow the junction of the dam and the right abutment. It then extends along the toe of the dam joining the original stream on which the dam is constructed just downstream of the dam.

(3) Spillway releases have caused erosion of the outlet channel adjacent to the embankment at the right abutment and along the toe of the dam.

d. Overtopping Potential. The spillways are inadequate to pass the probable maximum flood, or 1/2 the probable maximum flood, without overtopping the dam. The results of the dam overtopping analyses are as follows:

(Note: The data appearing in the following table has been extracted from the computer output data appearing in Appendix B. Decimal values have been rounded to the nearest one-tenth in order to prevent assumption of unwarranted accuracy.)

Ratio of PMF	Q-Peak Outflow (cfs)	Max. Lake W.S. Elev.	Max. Depth (Ft.) of Flow over Dam (Elev. 724.0)	Duaration of Overtopping of Dam (Hours)
0.50	549	724.9	0.9	7.2
1.00	1,142	725.3	1.3	10.2

Elevation 724.0 was found to be the lowest point in the dam crest. The flow safely passing the spillway, just prior to overtopping amounts to approximately 19 cfs, which is the routed outflow corresponding to about 14 percent of the probable maximum flood inflow. During peak flow of the probable maximum flood, the greatest depth of flow over the dam is projected to be 1.3 feet and overtopping will extend across the entire length of the dam.

e. Evaluation. Investigation of the surficial material of the dam indicated it to be a silty lean clay of low-to-medium plasticity. Experience indicates that this type of material, under certain conditions, such as high velocity flow, can be very erodible. An example of such erosion exists within the spillway outlet channel just downstream of the area protected by riprap as well as along the right abutment. A condition favorable for erosion exists during the PMF when large lake outflow, accompanied by high flow velocities, occurs. For the PMF condition where the depth of flow over the dam crest, a maximum of 1.3 feet, and the duration of flow over the dam, 10.2 hours, are

appreciable, damage by erosion to the crest and downstream face of the dam is expected. The extent of these damages is not predictable within the scope of these investigations; however, there is a possibility that they could result in failure by erosion of the dam. A similar condition, although not quite as severe, also exists during the 1/2 PMF event.

f. Reference. Procedures and data for determining the probable maximum flood, the 1 percent probability flood, and the discharge rating curve for flow passing the spillways are presented on pages B-1 and B-2 of the Appendix. Listings of the HEC-1 (Dam Safety Version) input data for both the probable maximum flood and the 1 percent probability flood are shown on pages B-3 through B-5. Computer output data, including unit hydrograph ordinates, tabulation of PMF rainfall, loss and inflow data are shown on pages B-6 through B-9; tabulation of lake surface area, elevation and storage volume is shown on page B-10; and tabulations titled "Summary of Dam Safety Analysis" for the PMF and 1 percent probability (100-year frequency) flood are also shown on page B-10.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which adversely affect the structural stability of the dam are discussed in Section 3, paragraph 3.1c.

b. Design and Construction Data. No design or construction data relating to the structural stability of the dam are known to exist. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Operating Records. No appurtenant structures or facilities requiring operation exist at this dam. According to the Owner, no records are kept of the lake level, spillway discharge, dam settlement, or seepage.

d. Post Construction Changes. As discussed in Section 4, paragraph 4.2, in 1979, the culvert type spillway with two 15-inch pipes was installed at the location of the original outlet, an excavated earth section, in order to prevent erosion of the roadway which crosses the spillway. According to the Owner, no other post construction changes are known to have been made or have occurred which would affect the structural stability of the dam.

e. Seismic Stability. The dam is located in an area close to the boundary separating the Zone I and Zone II seismic probability areas. An earthquake of the magnitude that might occur in this area would not be expected to cause structural damage to a well-constructed earth dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading be applied in any stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. A hydraulic analysis indicated that the spillways are capable of passing lake outflow of about 19 cfs without the level of the lake exceeding the low point in the top of the dam. A hydrologic analysis of the lake watershed area, as discussed in Section 5, paragraph 5.1d, indicated that for storm runoff of probable maximum flood magnitude, the recommended spillway design flood for this dam, the lake outflow would be about 1,142 cfs, and that for the 1 percent probability (100-year frequency) flood, the lake outflow would be about 17 cfs.

Seepage and stability analyses of the dam were not available for review, and therefore, no judgment could be made with respect to the structural stability of the dam.

Significant items noticed during the inspection that could adversely affect the safety of the dam were the erosion adjacent to the embankment at the right abutment and the toe of the dam, the embankment erosion at the left abutment, the lack of adequate slope protection to prevent erosion of the upstream face of the dam, seepage, old animal burrows at the upstream face of the dam, and the small trees on the downstream face of the dam.

b. Adequacy of Information. Due to lack of design and construction data, the assessments reported herein were based on external conditions as determined during the visual inspection. The assessments of the hydrology of the watershed and capacities of the spillways were based on a hydraulic/hydrologic study as indicated in Section 5. Seepage and stability analyses comparable to the requirements of "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. The remedial measures recommended in paragraph 7.2 for the items concerning the safety of the dam noted in paragraph 7.1a should be accomplished without undue delay. The item recommended in paragraph 7.2a concerning the provision of additional spillway capacity should be pursued on a high priority basis.

d. Necessity for Phase II. Based on the results of the Phase I inspection, Phase II investigation is not recommended.

e. Seismic Stability. The dam is located in an area close to the boundary separating the Zone I and Zone II seismic probability areas. An earthquake of the magnitude that might occur in this area would not be expected to cause structural damage to a well constructed earth dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES

a. Recommendations. The following actions are recommended.

(1) Based upon criteria set forth in the recommended guidelines, spillway size and/or height of dam should be increased in order to pass lake outflow resulting from a storm of probable maximum flood magnitude, which is the recommended spillway design flood for this dam. In either case, the spillway should be protected to prevent erosion.

(2) Obtain the necessary soil data and perform dam seepage and stability analyses in order to determine the structural stability of the dam for all operational conditions. Seepage and stability analyses should be performed by a qualified professional engineer experienced in the design and construction of earthen dams.

b. Operations and Maintenance (O & M) Procedures. The following O & M Procedures are recommended:

(1) Restore the eroded areas within the spillway outlet channel, at the right abutment, at the toe of the dam, and along the left abutment, and provide some form of protection in order to prevent erosion by spillway releases and stormwater runoff. Loss of embankment material or material adjacent to the embankment by erosion can impair the structural stability of

the dam. Spillway releases should not be permitted to impinge upon the dam since high velocity flow will result in erosion of the embankment. Spillway flows should be confined to areas where damage to the dam or areas adjacent to the dam will not occur.

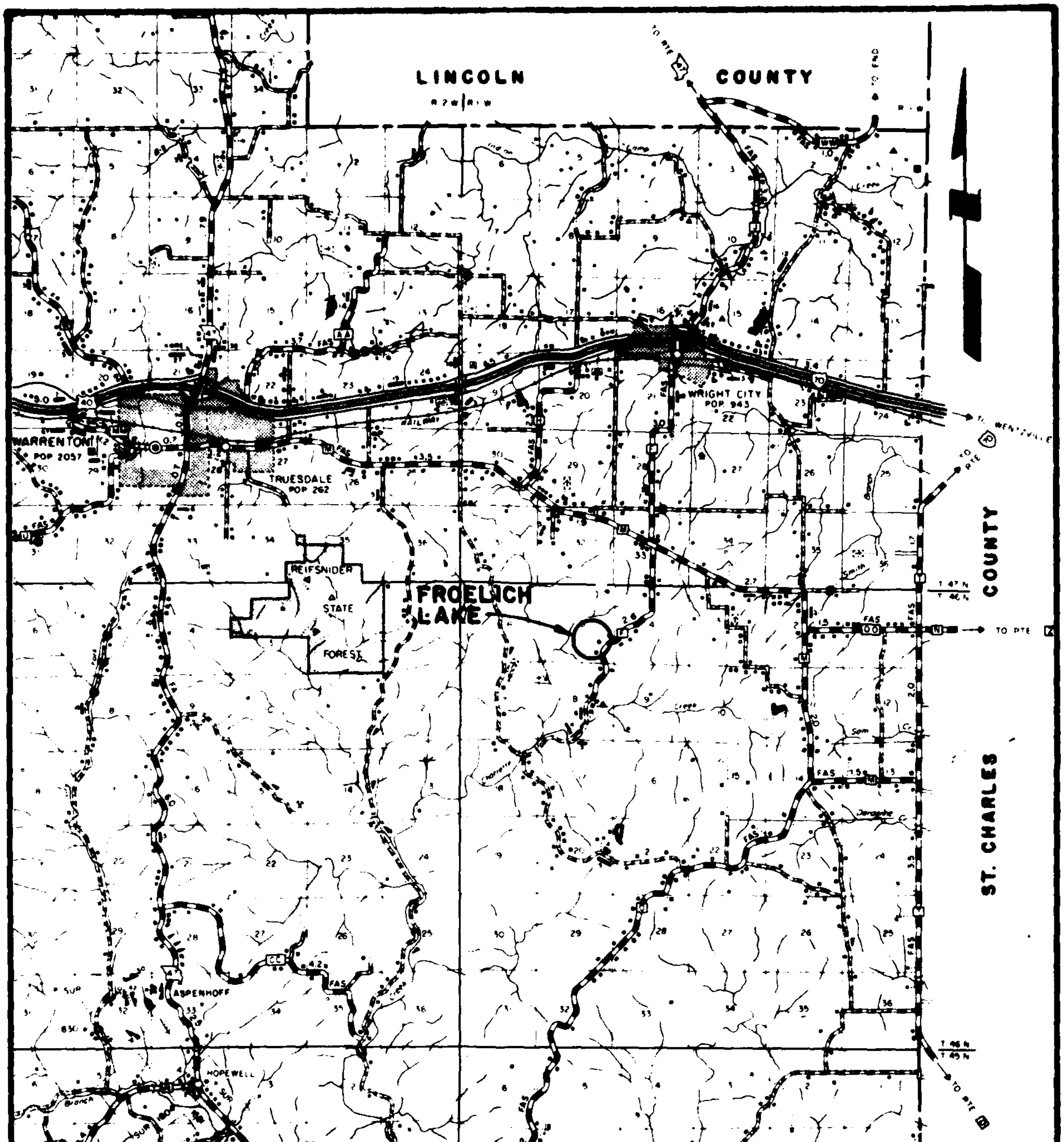
(2) Restore the eroded areas and the places damaged by burrowing animals along the upstream face of the dam. Provide some form of protection other than grass at and above the normal waterline in order to prevent erosion. A grass covered slope is not considered adequate protection to prevent erosion of the embankment by wave action or by a fluctuating lake level.

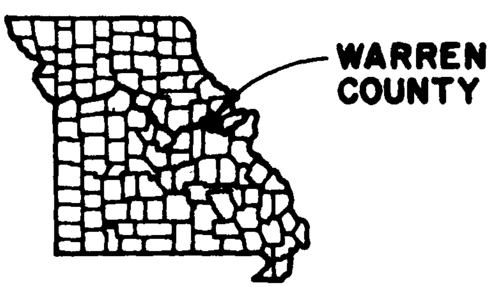
(3) Provide some means of controlling seepage evident in the area near the left abutment at the toe of the dam. Uncontrolled seepage can lead to a piping condition (progressive internal erosion) which could result in failure of the dam.

(4) Remove the trees from the downstream face of the dam. Tree roots can provide passageways for lake seepage that could lead to a piping condition and failure of the dam.

(5) Provide maintenance of all areas of the dam including periodic cutting of the grass on the downstream slope, on a regularly scheduled basis in order to insure features of being in satisfactory operational condition.

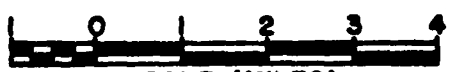
(6) A detailed inspection of the dam should be instituted on a regular basis by an engineer experienced in the design and construction of dams. It is also recommended, for future reference, that records be kept of all inspections made and remedial measures taken.





LOCATION MAP

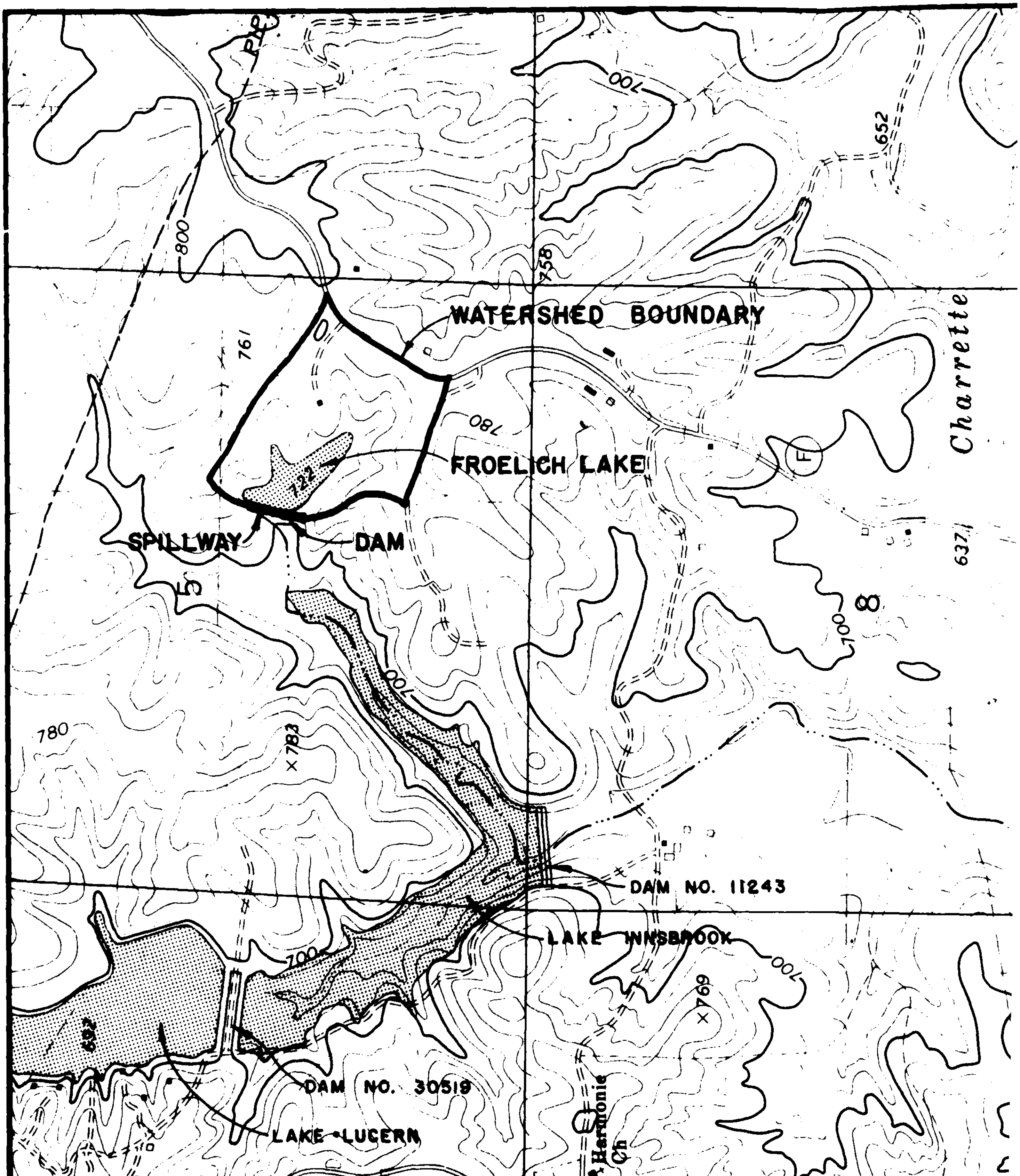
FROELICH LAKE



SCALE (MILES)

REGIONAL VICINITY MAP

PLATE I


WATERSHED BOUNDARY
FROELICH LAKE
SPILLWAY
DAM
DAM NO. 11243
LAKE INNSBROOK
DAM NO. 30519
LAKE LUCERN
Charrette
Harmonie Ch
800
761
758
780
722
700
652
637
783
780
769
692

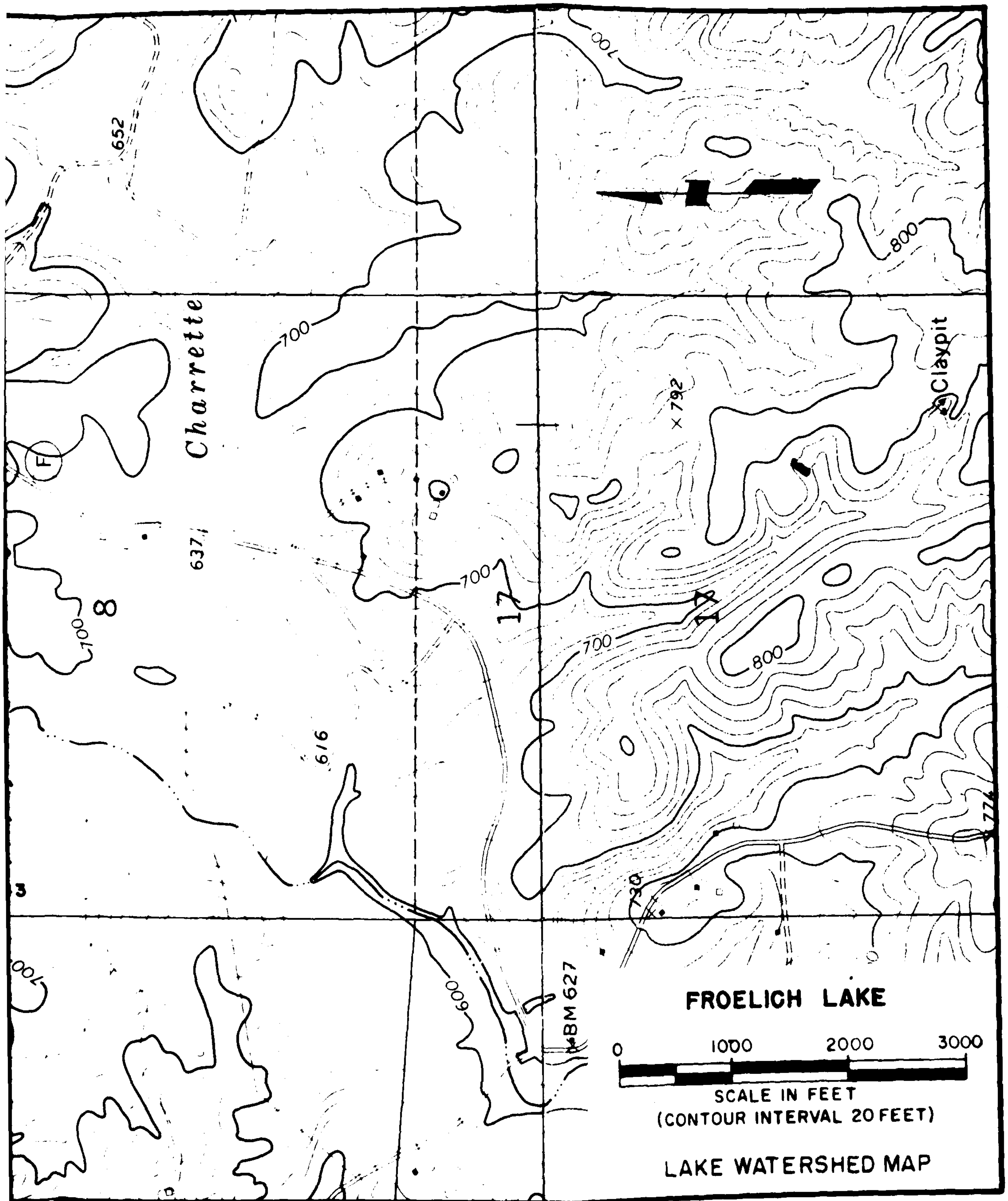
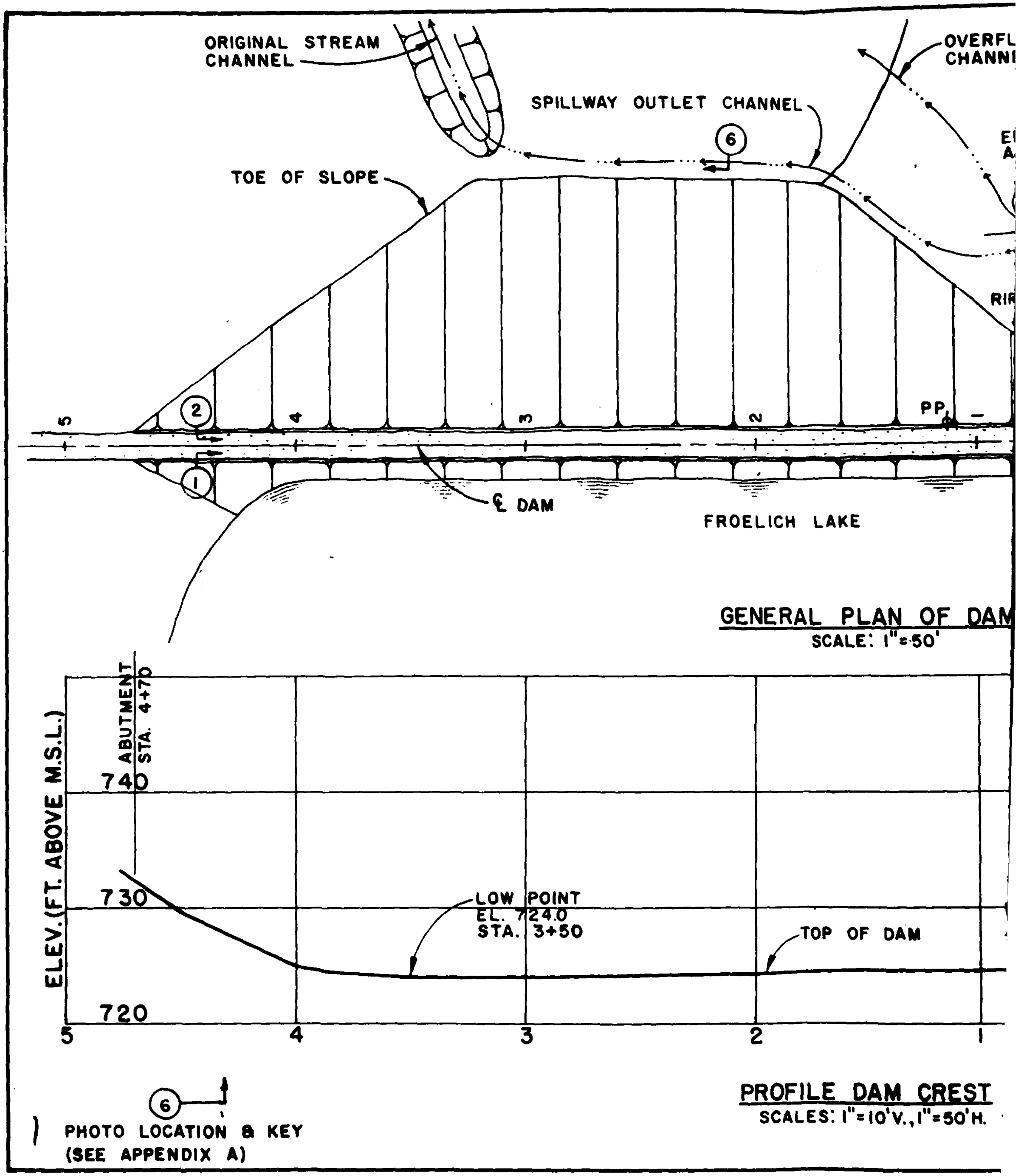
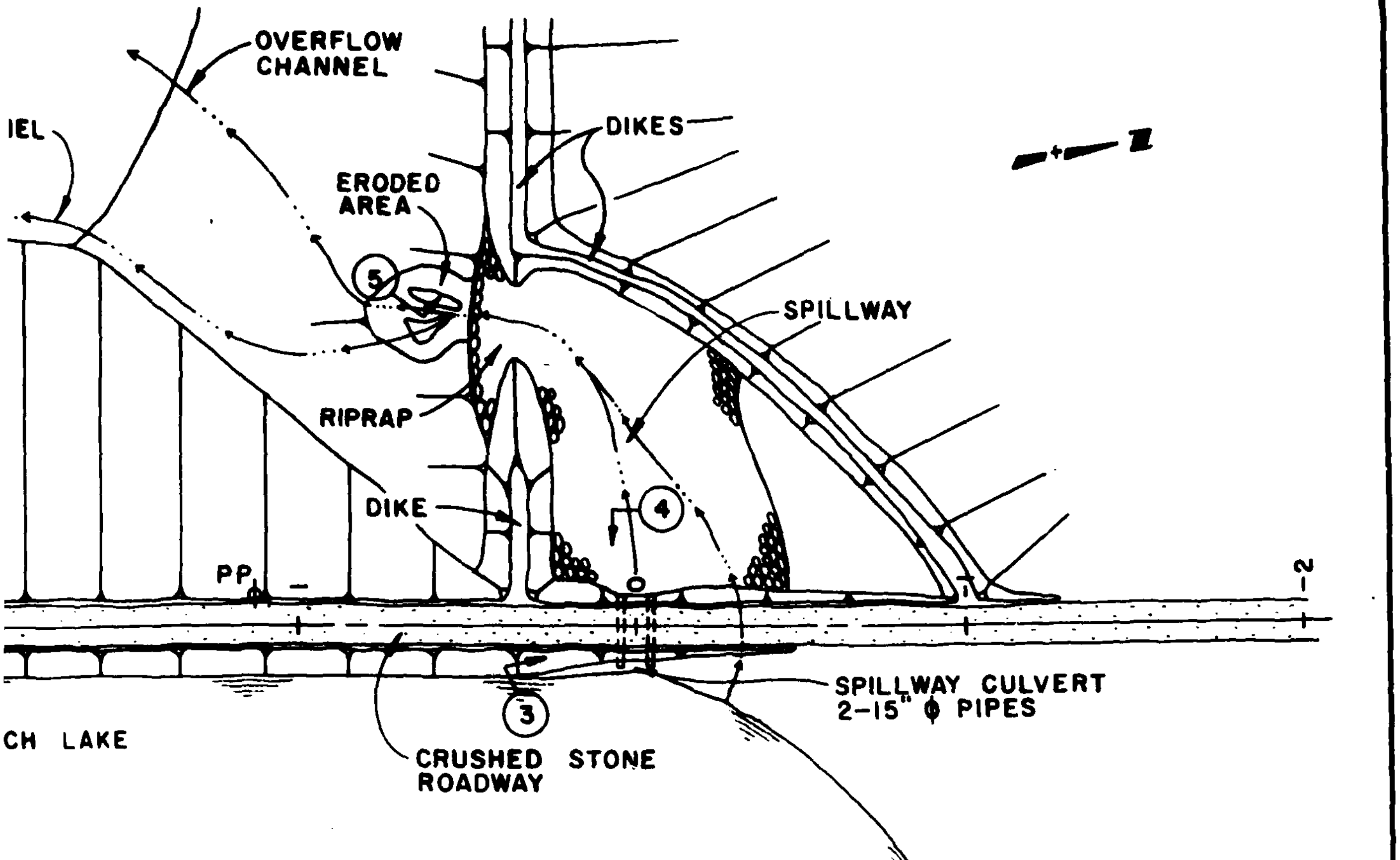
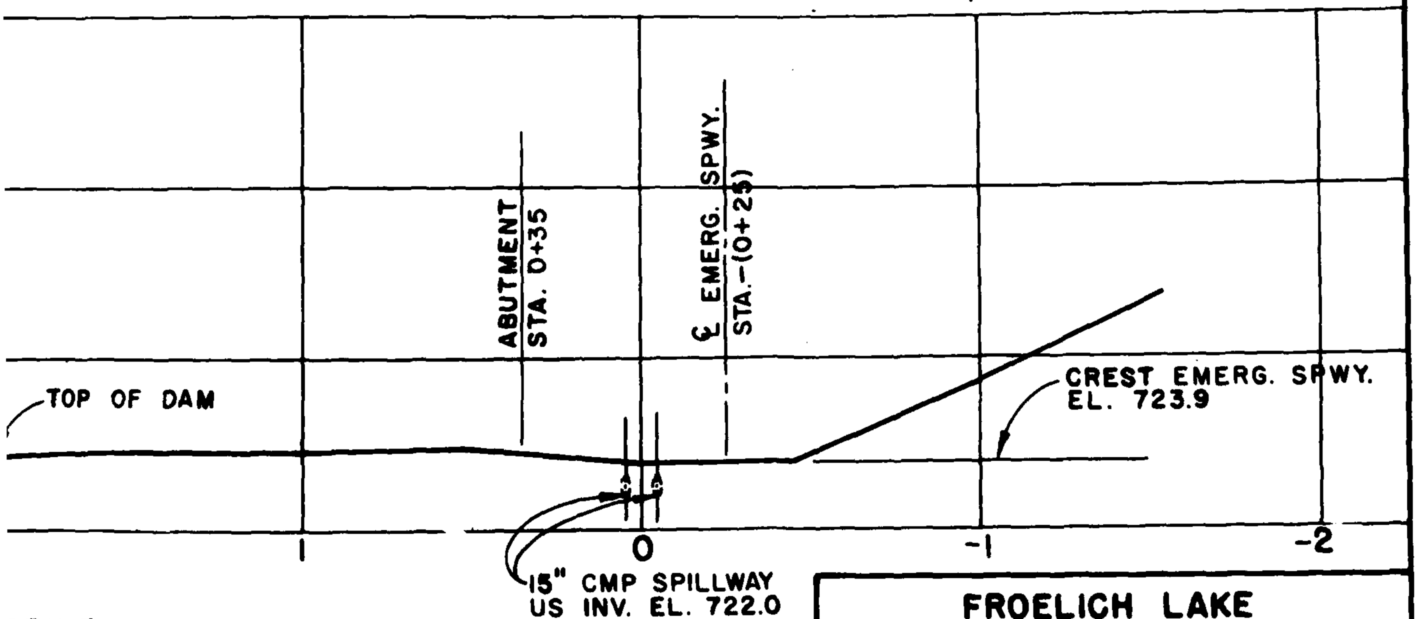

FROELICH LAKE
0
1000
2000
3000
SCALE IN FEET
(CONTOUR INTERVAL 20 FEET)
LAKE WATERSHED MAP
Charrette
Claypit
BM 627
700
800
600
652
637
616
792
774
730
8
17
3

PLATE 2


ORIGINAL STREAM CHANNEL
SPILLWAY OUTLET CHANNEL
OVERFL
CHANN
TOE OF SLOPE
6
2
1
5
4
3
2
PP
℄ DAM
FROELICH LAKE
RIF
GENERAL PLAN OF DAM
SCALE: 1"=50'
ABUTMENT STA. 4+70
ELEV. (FT. ABOVE M.S.L.)
740
730
720
LOW POINT
EL. 724.0
STA. 3+50
TOP OF DAM
5
4
3
2
1
PROFILE DAM CREST
SCALES: 1"=10'V., 1"=50'H.
6
PHOTO LOCATION & KEY
(SEE APPENDIX A)



:RAL PLAN OF DAM
SCALE: 1"=50'



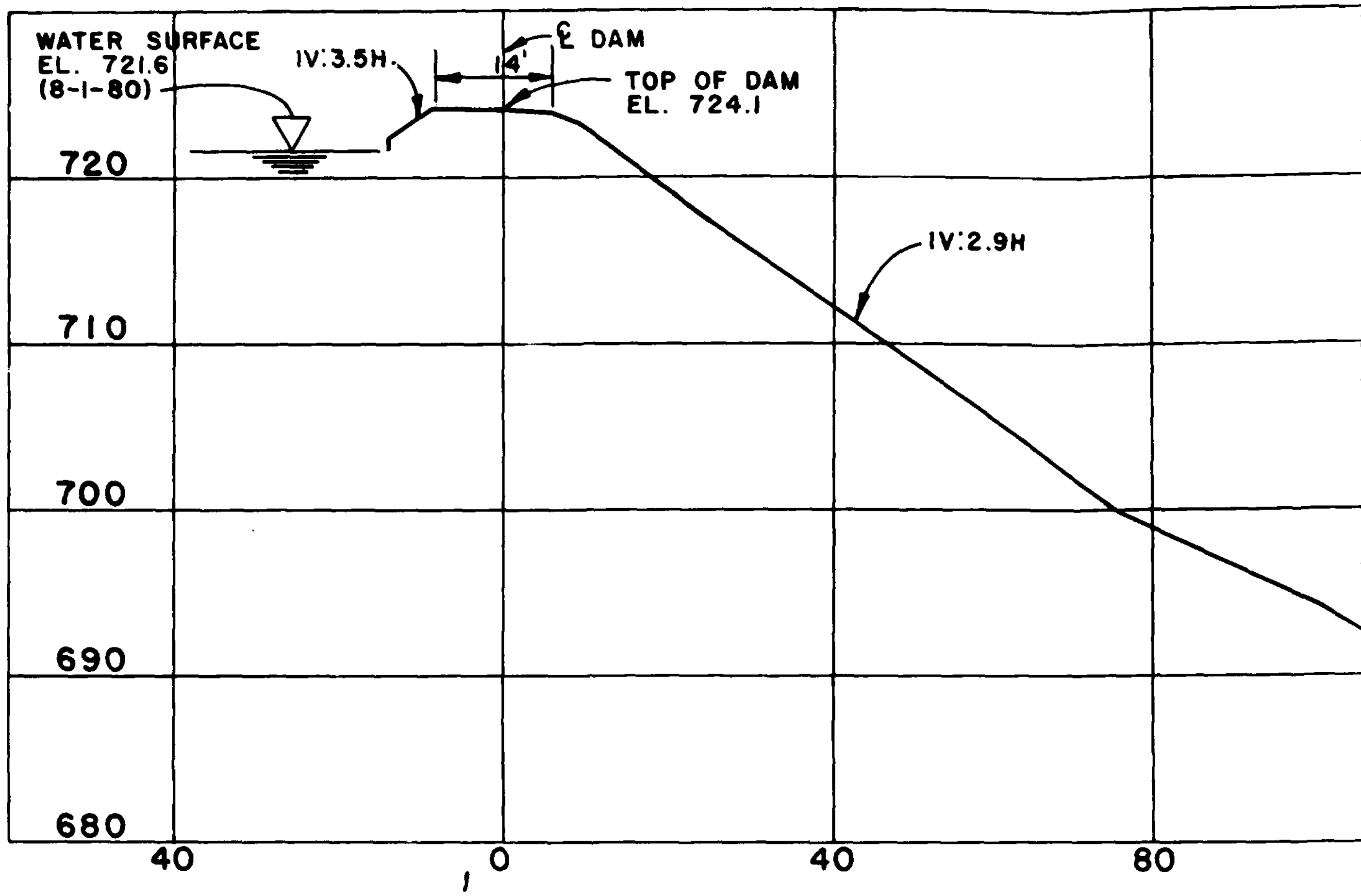
DFILE DAM CREST
:ALES: 1"=10'V., 1"=50'H.

2

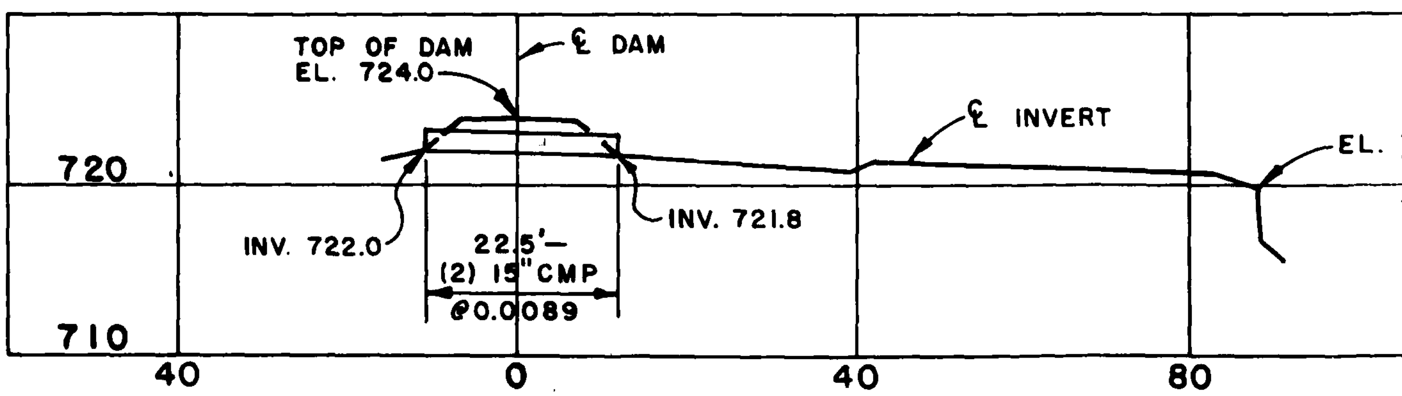
FROELICH LAKE
DAM PLAN & PROFILE

Horner & Shifrin, Inc. August 1980

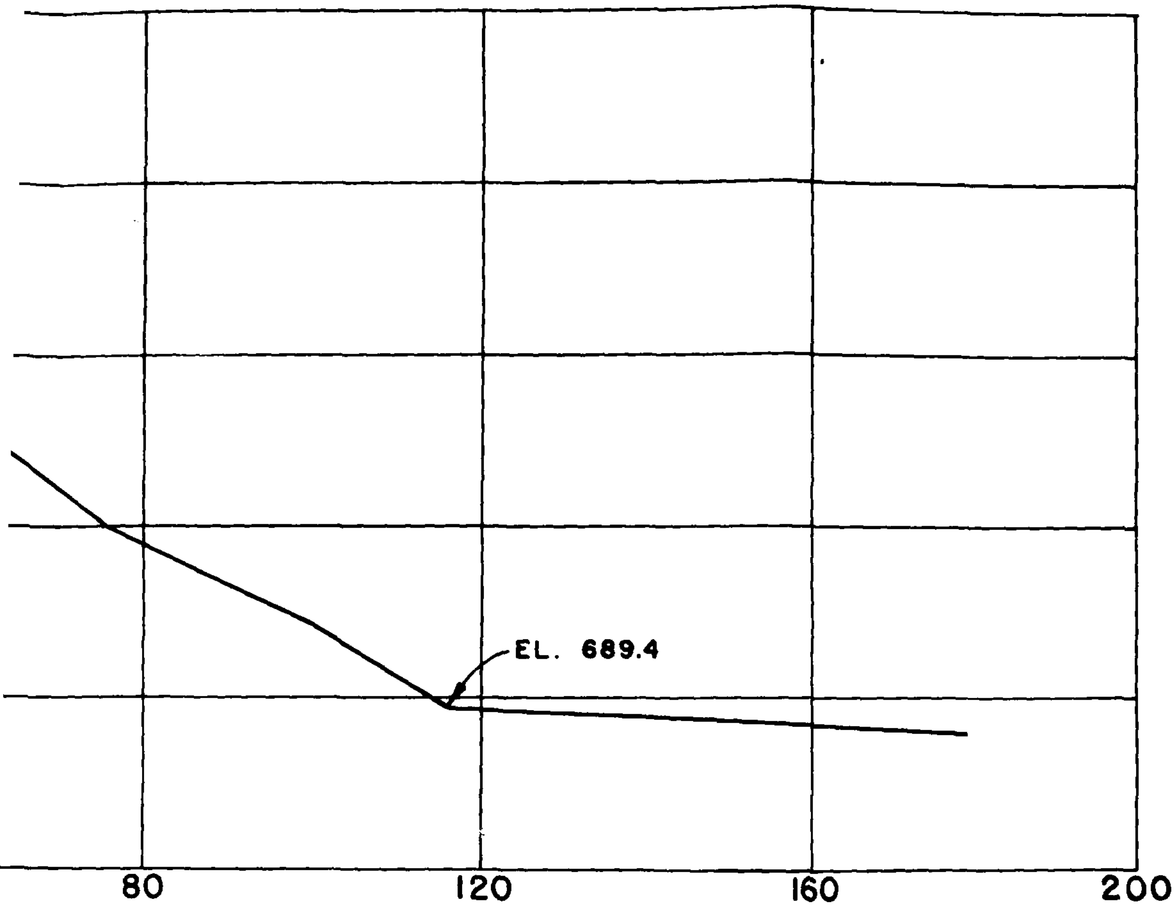
PLATE 3



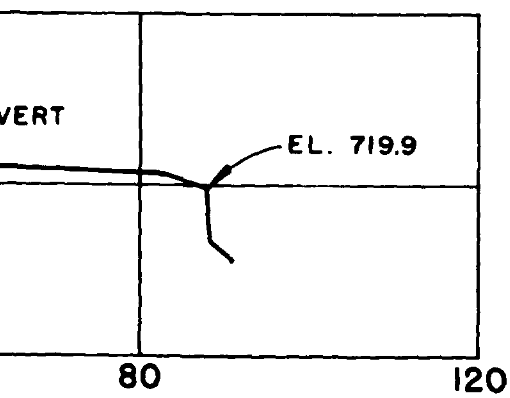
DAM CROSS-SECTION STA. 3+00
SCALES: 1"=10'V., 1"=20'H.



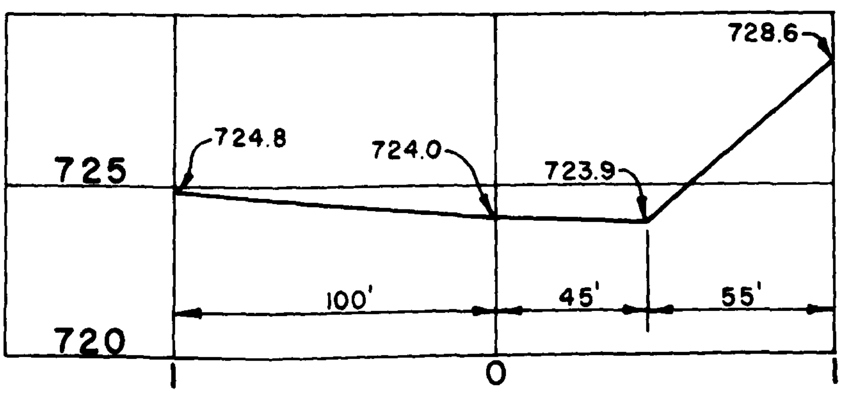
PROFILE PRINCIPAL SPILLWAY
SCALES: 1"=10'V., 1"=20'H.



SECTION STA. 3+00
S: 1"=10'V., 1"=20'H.



LWAY



EMERGENCY SPILLWAY
CROSS-SECTION – ℄ DAM
SCALES: 1"=5'V., 1"=50'H.

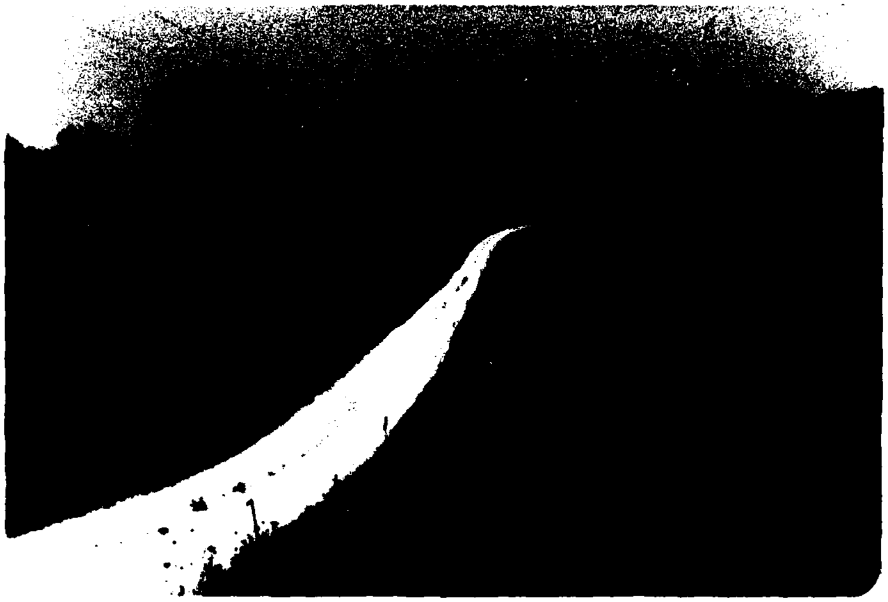
2

FROELICH LAKE
DAM CROSS-SECTION
SPILLWAY PROFILE & SECTION
Horner & Shifrin, Inc. August 1980

PLATE 4

APPENDIX A

INSPECTION PHOTOGRAPHS



NO. 1: UPSTREAM FACE OF DAM

NO. 2: DOWNSTREAM FACE OF DAM

NO. 3: UPSTREAM END OF SPILLWAY PIPES AND EMERGENCY SPILLWAY CHANNEL

NO. 4: DOWNSTREAM END OF SPILLWAY PIPES


NO. 5: ERODED AREA IN SPILLWAY OUTLET CHANNEL


NO. 6: EROSION OF SPILLWAY OUTLET CHANNEL NEAR TOE OF DAM

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

1. The HEC-1 Dam Safety Version (July 1978, Modified 26 February 1979) program was used to develop inflow and outflow hydrographs and dam overtopping analyses, with hydrologic inputs as follows:

a. Probable maximum precipitation (200 sq. mile, 24-hour value equals 25.0 inches) from Hydrometeorological Report No. 33. The precipitation data used in the analysis of the 1 percent probability (100-year frequency) flood was provided by the St. Louis District, Corps of Engineers.

b. Drainage area = 0.079 square miles = 51 acres.

c. SCS parameters:

Time of Concentration $(T_c) = \left(\frac{11.9L^3}{H}\right)^{0.385} = 0.092$ hours

Where: T_c = Travel time of water from hydraulically most distant point to point of interest, hours.

L = Length of longest watercourse, 0.227 miles

H = Elevation difference, 68 feet

The time of concentration (Tc) was obtained using Method C as described in Figure 30, "Design of Small Dams", by the United States Department of the Interior, Bureau of Reclamation, and was verified using average channel velocity estimates and watercourse lengths.

Lag Time = 0.055 hours (0.60 T_c)

Hydrologic Soil Group = 95% C (Lindley Series) + 5% D (Keswick Series) per County SCS Soil Report

Soil type CN = 78 (AMC II, 1 percent probability flood condition)
= 90 (AMC III, PMF condition)

2. For the double 15-inch diameter spillway outlet pipes, flow was determined using Bernoulli's equation for pressure flow in pipes. A friction factor (n) of 0.021 was used for the 15-inch diameter corrugated metal pipes. Losses, including entrance, pipe friction, and exit losses

totaled 2.46 velocity heads. Reference "Handbook of Hydraulics", Fifth Edition, by King & Brater, pages 8-5 and 8-6.

Discharge quantities, determined by the method described herein were plotted versus corresponding lake water surface elevations to determine the discharge rating curve for the pipe spillway.

3. The emergency spillway section consists of a broad-crested, dish-shaped section for which conventional weir formulas do not apply.

Spillway release rates were determined as follows:

a. Spillway crest section properties (areas, "a", and top width, "t") were computed for various depths, "d".

b. It was assumed that flow over the spillway crest would occur at critical depth. Flow at critical depth was computed as $Qc = \frac{a^3 g}{t}^{0.5}$ for the various depths, "d". Corresponding velocities (v_c) and velocity heads (H_{vc}) were determined using conventional formulas.* Reference, "Handbook of Hydraulics", Fifth Edition, by King & Brater, page 8-7.

c. Static lake levels corresponding to the various flow values passing the spillway were computed as critical depths plus critical velocity heads ($d_c + H_{vc}$), and the relationship between lake level and spillway discharge was thus obtained. The procedure neglects the minor insignificant friction losses across the length of the spillway.

d. The discharges for the principal and emergency spillways for equal elevations were summated for entry on the Y4 and Y5 cards.

4. The profile of the dam crest is irregular and flow over the dam cannot be determined by application of conventional weir formulas. Crest length and elevation data for the dam crest proper were entered into the HEC-1 Program on the $L and the $V cards. The program assumes that flow over the dam crest section occurs at critical depth and computes internally the flow over the dam crest and adds this flow to the flow over the spillways as entered on the Y4 and Y5 cards.

* $v_c = \frac{Qc}{a}$; $Hvc = \frac{v_c^2}{2g}$

```
A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF FROELICH LAKE DAM
A3       RATIOS OF PMF ROUTED THROUGH RESERVOIR
B     288       0       5       0       0       0       0       0       0       0
B1      5
J       1       4       1
J1    .14     .15     .50      1.
K       0  INFLOW                                       1
K1       INFLOW HYDROGRAPH
M       1       2    .079                     1.0                          1
P       0    25.0     102     120     130
T                                                      -1    -90
W2          0.055
X    -1.0    -.10     2.0
K       1     DAM                                       1
K1       RESERVOIR ROUTING BY MODIFIED PULS
Y                             1       1
Y1      1                                           53.24      -1
Y4  722.0   723.0   723.9  724.59  725.20  726.02  726.74  727.46
Y5      0     8.2    13.2    51.5   294.7   710.4  1247.4  1890.5
$A      0    5.85     9.2    17.7    19.7   24.70
$E  354.7     722     730     740     750     760
$$    722
$D    724
$L      0     117     178     200     232     243     350     387
$V    724   724.3   724.4   724.5   724.6   724.7   724.8   724.9
K      99
```

```
A1       ANALYSIS OF DAM OVERTOPPING USING 100-YR FLOOD
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF FROELICH LAKE DAM
A3       100-YR FLOOD ROUTED THROUGH RESERVOIR
B     208        0        5                                                     4
B1      5
J       1        1        1
J1     1.
K       0   INFLOW                                            1
K1       INFLOW HYDROGRAPH
M       0        2     .079                          1.0                        1
O     288    7.094
01   .006     .006     .006     .006     .006     .006     .006     .006     .006     .006
01   .006     .006     .006     .006     .006     .006     .006     .006     .006     .006
01   .006     .006     .006     .006     .006     .006     .006     .006     .006     .006
01   .006     .006     .006     .006     .006     .006     .006     .006     .006     .006
01   .006     .006     .006     .006     .006     .006     .006     .006     .006     .006
01   .006     .006     .006     .006     .006     .006     .006     .006     .006     .006
01   [illegible] .006  .006     .006     .006     .006     .006     .006     .006     .006
01   .006     .006     .014     .014     .014     .014     .014     .014     .014     .014
01   .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
01   .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
01   .014     .014     .014     .014     .014     .014     .014     .014     .024     .024
01   .024     .024     .024     .024     .024     .024     .024     .024     .024     .024
01   .024     .024     .024     .024     .024     .024     .029     .029     .029     .029
01   .029     .029     .060     .060     .060     .060     .060     .060     .127     .127
01   .130     .247     .247     .546     .826     .380     .247     .130     .130     .130
01   .060     .060     .060     .060     .060     .060     .029     .029     .029     .029
01   .029     .029     .024     .024     .024     .024     .024     .024     .024     .024
```

100-YEAR FLOOD (Cont'd)

01	.024	.024	.024	.024	.024	.024	.024	.024	.024	.024
01	.014	.014	.014	.014	.014	.014	.014	.014	.014	.014
01	.014	.014	.014	.014	.014	.014	.014	.014	.014	.014
01	.014	.014	.014	.014	.014	.014	.014	.014	.014	.014
01	.014	.014	.014	.014	.014	.014	.006	.006	.006	.006
01	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
01	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
01	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
01	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
01	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
01	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
01	.006	.006	.006	.006	.006	.006	.006	.006		
T							-1	-78		
W2		0.055								
X	-1.0	-.10	2.0							
K	1	DAM					1			
K1	RESERVOIR ROUTING BY MODIFIED PULS									
Y				1	1					
Y1	1						53.24	-1		
Y4	722.0	723.0	723.9	724.59	725.29	726.02	726.74	727.46		
Y5	0	8.2	13.2	51.5	294.7	710.4	1247.4	1896.5		
$A	0	5.85	9.2	17.7	19.2	24.79				
$E	694.7	722	730	740	750	760				
$$	722									
$D	724									
$L	0	117	178	200	232	243	350	387		
$V	724	724.3	724.4	724.5	724.6	724.7	724.8	728.6		
K	99									

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF FROELICH LAKE DAM
RATIOS OF PMF ROUTED THROUGH RESERVOIR

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	5	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 4 LRTIO= 1
RTIOS= .14 .15 .50 1.00

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SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
INFLOW	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	0	.08	0.00	.08	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.00	102.00	120.00	130.00	0.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-90.00	0.00	0.00

CURVE NO = -90.00 WETNESS = -1.00 EFFECT CN = 90.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .06

RECESSION DATA
STRTQ= -1.00 QRCSN= -.10 RTIOR= 2.00

TIME INCREMENT TOO LARGE--(NHQ IS GT LAG/2)

UNIT HYDROGRAPH 5 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .06 VOL= 1.00
380. 174. 43. 11. 3.

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	0.	1.01	12.05	145	.21	.21	.01	92.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.10	146	.21	.21	.01	118.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.15	147	.21	.21	.01	125.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.20	148	.21	.21	.01	126.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.25	149	.21	.21	.00	127.
1.01	.30	6	.01	0.00	.01	0.	1.01	12.30	150	.21	.21	.00	127.
1.01	.35	7	.01	0.00	.01	0.	1.01	12.35	151	.21	.21	.00	127.
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.21	.21	.00	127.
1.01	.45	9	.01	0.00	.01	0.	1.01	12.45	153	.21	.21	.00	127.
1.01	.50	10	.01	0.00	.01	0.	1.01	12.50	154	.21	.21	.00	128.
1.01	.55	11	.01	0.00	.01	0.	1.01	12.55	155	.21	.21	.00	128.
1.01	1.00	12	.01	0.00	.01	0.	1.01	13.00	156	.21	.21	.00	128.
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.05	157	.26	.25	.00	144.
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.10	158	.26	.25	.00	151.
1.01	1.15	15	.01	0.00	.01	0.	1.01	13.15	159	.26	.25	.00	153.
1.01	1.20	16	.01	0.00	.01	0.	1.01	13.20	160	.26	.25	.00	154.
1.01	1.25	17	.01	.00	.01	0.	1.01	13.25	161	.26	.25	.00	154.
1.01	1.30	18	.01	.00	.01	0.	1.01	13.30	162	.26	.25	.00	154.
1.01	1.35	19	.01	.00	.01	0.	1.01	13.35	163	.26	.25	.00	154.
1.01	1.40	20	.01	.00	.01	1.	1.01	13.40	164	.26	.25	.00	154.
1.01	1.45	21	.01	.00	.01	1.	1.01	13.45	165	.26	.25	.00	154.
1.01	1.50	22	.01	.00	.01	1.	1.01	13.50	166	.26	.25	.00	154.
1.01	1.55	23	.01	.00	.01	1.	1.01	13.55	167	.26	.25	.00	154.
1.01	2.00	24	.01	.00	.01	1.	1.01	14.00	168	.26	.25	.00	155.
1.01	2.05	25	.01	.00	.01	1.	1.01	14.05	169	.32	.32	.00	179.
1.01	2.10	26	.01	.00	.01	2.	1.01	14.10	170	.32	.32	.00	190.
1.01	2.15	27	.01	.00	.01	2.	1.01	14.15	171	.32	.32	.00	193.
1.01	2.20	28	.01	.00	.01	2.	1.01	14.20	172	.32	.32	.00	193.
1.01	2.25	29	.01	.00	.01	2.	1.01	14.25	173	.32	.32	.00	194.
1.01	2.30	30	.01	.00	.01	2.	1.01	14.30	174	.32	.32	.00	194.
1.01	2.35	31	.01	.00	.01	2.	1.01	14.35	175	.32	.32	.00	194.
1.01	2.40	32	.01	.00	.01	2.	1.01	14.40	176	.32	.32	.00	194.
1.01	2.45	33	.01	.00	.01	3.	1.01	14.45	177	.32	.32	.00	194.
1.01	2.50	34	.01	.00	.01	3.	1.01	14.50	178	.32	.32	.00	194.
1.01	2.55	35	.01	.00	.01	3.	1.01	14.55	179	.32	.32	.00	194.
1.01	3.00	36	.01	.00	.01	3.	1.01	15.00	180	.32	.32	.00	194.
1.01	3.05	37	.01	.01	.01	3.	1.01	15.05	181	.19	.19	.00	147.
1.01	3.10	38	.01	.01	.01	3.	1.01	15.10	182	.39	.39	.00	198.
1.01	3.15	39	.01	.01	.01	3.	1.01	15.15	183	.39	.39	.00	227.
1.01	3.20	40	.01	.01	.01	3.	1.01	15.20	184	.58	.58	.00	307.
1.01	3.25	41	.01	.01	.01	3.	1.01	15.25	185	.68	.68	.00	379.
1.01	3.30	42	.01	.01	.01	4.	1.01	15.30	186	1.65	1.64	.01	773.
1.01	3.35	43	.01	.01	.01	4.	1.01	15.35	187	2.71	2.71	.01	1352.
1.01	3.40	44	.01	.01	.01	4.	1.01	15.40	188	1.07	1.06	.00	956.
1.01	3.45	45	.01	.01	.01	4.	1.01	15.45	189	.68	.68	.00	579.
1.01	3.50	46	.01	.01	.01	4.	1.01	15.50	190	.58	.58	.00	418.
1.01	3.55	47	.01	.01	.01	4.	1.01	15.55	191	.39	.39	.00	297.
1.01	4.00	48	.01	.01	.01	4.	1.01	16.00	192	.39	.39	.00	250.
1.01	4.05	49	.01	.01	.01	4.	1.01	16.05	193	.30	.30	.00	205.

END-OF-PERIOD FLOW (Cont'd)

1.01	4.10	50	.01	.01	.01	4.
1.01	4.15	51	.01	.01	.01	4.
1.01	4.20	52	.01	.01	.01	4.
1.01	4.25	53	.01	.01	.01	4.
1.01	4.30	54	.01	.01	.01	5.
1.01	4.35	55	.01	.01	.01	5.
1.01	4.40	56	.01	.01	.01	5.
1.01	4.45	57	.01	.01	.01	5.
1.01	4.50	58	.01	.01	.01	5.
1.01	4.55	59	.01	.01	.01	5.
1.01	5.00	60	.01	.01	.01	5.
1.01	5.05	61	.01	.01	.01	5.
1.01	5.10	62	.01	.01	.01	5.
1.01	5.15	63	.01	.01	.01	5.
1.01	5.20	64	.01	.01	.01	5.
1.01	5.25	65	.01	.01	.01	5.
1.01	5.30	66	.01	.01	.01	5.
1.01	5.35	67	.01	.01	.01	5.
1.01	5.40	68	.01	.01	.01	5.
1.01	5.45	69	.01	.01	.01	5.
1.01	5.50	70	.01	.01	.00	5.
1.01	5.55	71	.01	.01	.00	5.
1.01	6.00	72	.01	.01	.00	6.
1.01	6.05	73	.06	.04	.02	18.
1.01	6.10	74	.06	.04	.02	24.
1.01	6.15	75	.06	.04	.02	26.
1.01	6.20	76	.06	.05	.02	27.
1.01	6.25	77	.06	.05	.02	28.
1.01	6.30	78	.06	.05	.02	28.
1.01	6.35	79	.06	.05	.01	29.
1.01	6.40	80	.06	.05	.01	29.
1.01	6.45	81	.06	.05	.01	30.
1.01	6.50	82	.06	.05	.01	30.
1.01	6.55	83	.06	.05	.01	31.
1.01	7.00	84	.06	.05	.01	31.
1.01	7.05	85	.06	.05	.01	31.
1.01	7.10	86	.06	.05	.01	32.
1.01	7.15	87	.06	.05	.01	32.
1.01	7.20	88	.06	.05	.01	32.
1.01	7.25	89	.06	.05	.01	33.
1.01	7.30	90	.06	.05	.01	33.
1.01	7.35	91	.06	.05	.01	33.
1.01	7.40	92	.06	.05	.01	33.
1.01	7.45	93	.06	.05	.01	33.
1.01	7.50	94	.06	.06	.01	34.
1.01	7.55	95	.06	.06	.01	34.
1.01	8.00	96	.06	.06	.01	34.
1.01	8.05	97	.06	.06	.01	34.
1.01	8.10	98	.06	.06	.01	34.
1.01	8.15	99	.06	.06	.01	34.
1.01	8.20	100	.06	.06	.01	35.
1.01	8.25	101	.06	.06	.01	35.
1.01	8.30	102	.06	.06	.01	35.
1.01	16.10	194	.30	.30	.00	187.
1.01	16.15	195	.30	.30	.00	183.
1.01	16.20	196	.30	.30	.00	182.
1.01	16.25	197	.30	.30	.00	182.
1.01	16.30	198	.30	.30	.00	182.
1.01	16.35	199	.30	.30	.00	182.
1.01	16.40	200	.30	.30	.00	182.
1.01	16.45	201	.30	.30	.00	182.
1.01	16.50	202	.30	.30	.00	182.
1.01	16.55	203	.30	.30	.00	182.
1.01	17.00	204	.30	.30	.00	182.
1.01	17.05	205	.23	.23	.00	157.
1.01	17.10	206	.23	.23	.00	146.
1.01	17.15	207	.23	.23	.00	144.
1.01	17.20	208	.23	.23	.00	143.
1.01	17.25	209	.23	.23	.00	143.
1.01	17.30	210	.23	.23	.00	143.
1.01	17.35	211	.23	.23	.00	143.
1.01	17.40	212	.23	.23	.00	143.
1.01	17.45	213	.23	.23	.00	143.
1.01	17.50	214	.23	.23	.00	143.
1.01	17.55	215	.23	.23	.00	143.
1.01	18.00	216	.23	.23	.00	143.
1.01	18.05	217	.02	.02	.00	127.
1.01	18.10	218	.02	.02	.00	118.
1.01	18.15	219	.02	.02	.00	111.
1.01	18.20	220	.02	.02	.00	103.
1.01	18.25	221	.02	.02	.00	96.
1.01	18.30	222	.02	.02	.00	90.
1.01	18.35	223	.02	.02	.00	84.
1.01	18.40	224	.02	.02	.00	78.
1.01	18.45	225	.02	.02	.00	73.
1.01	18.50	226	.02	.02	.00	68.
1.01	18.55	227	.02	.02	.00	63.
1.01	19.00	228	.02	.02	.00	59.
1.01	19.05	229	.02	.02	.00	55.
1.01	19.10	230	.02	.02	.00	52.
1.01	19.15	231	.02	.02	.00	48.
1.01	19.20	232	.02	.02	.00	45.
1.01	19.25	233	.02	.02	.00	42.
1.01	19.30	234	.02	.02	.00	39.
1.01	19.35	235	.02	.02	.00	36.
1.01	19.40	236	.02	.02	.00	34.
1.01	19.45	237	.02	.02	.00	32.
1.01	19.50	238	.02	.02	.00	30.
1.01	19.55	239	.02	.02	.00	28.
1.01	20.00	240	.02	.02	.00	26.
1.01	20.05	241	.02	.02	.00	24.
1.01	20.10	242	.02	.02	.00	22.
1.01	20.15	243	.02	.02	.00	21.
1.01	20.20	244	.02	.02	.00	20.
1.01	20.25	245	.02	.02	.00	18.
1.01	20.30	246	.02	.02	.00	17.

END-OF-PERIOD FLOW (Cont'd)

1.01	8.35	103	.06	.06	.01	35.	1.01	20.35	247	.02	.02	.00	16.
1.01	8.40	104	.06	.06	.01	35.	1.01	20.40	248	.02	.02	.00	15.
1.01	8.45	105	.06	.06	.01	35.	1.01	20.45	249	.02	.02	.00	14.
1.01	8.50	106	.06	.06	.00	35.	1.01	20.50	250	.02	.02	.00	13.
1.01	8.55	107	.06	.06	.00	35.	1.01	20.55	251	.02	.02	.00	13.
1.01	9.00	108	.06	.06	.00	35.	1.01	21.00	252	.02	.02	.00	13.
1.01	9.05	109	.06	.06	.00	35.	1.01	21.05	253	.02	.02	.00	13.
1.01	9.10	110	.06	.06	.00	36.	1.01	21.10	254	.02	.02	.00	13.
1.01	9.15	111	.06	.06	.00	36.	1.01	21.15	255	.02	.02	.00	13.
1.01	9.20	112	.06	.06	.00	36.	1.01	21.20	256	.02	.02	.00	13.
1.01	9.25	113	.06	.06	.00	36.	1.01	21.25	257	.02	.02	.00	13.
1.01	9.30	114	.06	.06	.00	36.	1.01	21.30	258	.02	.02	.00	13.
1.01	9.35	115	.06	.06	.00	36.	1.01	21.35	259	.02	.02	.00	13.
1.01	9.40	116	.06	.06	.00	36.	1.01	21.40	260	.02	.02	.00	13.
1.01	9.45	117	.06	.06	.00	36.	1.01	21.45	261	.02	.02	.00	13.
1.01	9.50	118	.06	.06	.00	36.	1.01	21.50	262	.02	.02	.00	13.
1.01	9.55	119	.06	.06	.00	36.	1.01	21.55	263	.02	.02	.00	13.
1.01	10.00	120	.06	.06	.00	36.	1.01	22.00	264	.02	.02	.00	13.
1.01	10.05	121	.06	.06	.00	36.	1.01	22.05	265	.02	.02	.00	13.
1.01	10.10	122	.06	.06	.00	36.	1.01	22.10	266	.02	.02	.00	13.
1.01	10.15	123	.06	.06	.00	36.	1.01	22.15	267	.02	.02	.00	13.
1.01	10.20	124	.06	.06	.00	36.	1.01	22.20	268	.02	.02	.00	13.
1.01	10.25	125	.06	.06	.00	36.	1.01	22.25	269	.02	.02	.00	13.
1.01	10.30	126	.06	.06	.00	36.	1.01	22.30	270	.02	.02	.00	13.
1.01	10.35	127	.06	.06	.00	37.	1.01	22.35	271	.02	.02	.00	13.
1.01	10.40	128	.06	.06	.00	37.	1.01	22.40	272	.02	.02	.00	13.
1.01	10.45	129	.06	.06	.00	37.	1.01	22.45	273	.02	.02	.00	13.
1.01	10.50	130	.06	.06	.00	37.	1.01	22.50	274	.02	.02	.00	13.
1.01	10.55	131	.06	.06	.00	37.	1.01	22.55	275	.02	.02	.00	13.
1.01	11.00	132	.06	.06	.00	37.	1.01	23.00	276	.02	.02	.00	13.
1.01	11.05	133	.06	.06	.00	37.	1.01	23.05	277	.02	.02	.00	13.
1.01	11.10	134	.06	.06	.00	37.	1.01	23.10	278	.02	.02	.00	13.
1.01	11.15	135	.06	.06	.00	37.	1.01	23.15	279	.02	.02	.00	13.
1.01	11.20	136	.06	.06	.00	37.	1.01	23.20	280	.02	.02	.00	13.
1.01	11.25	137	.06	.06	.00	37.	1.01	23.25	281	.02	.02	.00	13.
1.01	11.30	138	.06	.06	.00	37.	1.01	23.30	282	.02	.02	.00	13.
1.01	11.35	139	.06	.06	.00	37.	1.01	23.35	283	.02	.02	.00	13.
1.01	11.40	140	.06	.06	.00	37.	1.01	23.40	284	.02	.02	.00	13.
1.01	11.45	141	.06	.06	.00	37.	1.01	23.45	285	.02	.02	.00	13.
1.01	11.50	142	.06	.06	.00	37.	1.01	23.50	286	.02	.02	.00	13.
1.01	11.55	143	.06	.06	.00	37.	1.01	23.55	287	.02	.02	.00	13.
1.01	12.00	144	.06	.06	.00	37.	1.02	0.00	288	.02	.02	.00	13.
									SUM	32.50	31.20	1.30	20309.
										(825.)	(793.)	(33.)	(575.09)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1352.	215.	[illegible]	[illegible]	20285.
CMS	38.	6.	[illegible]	[illegible]	574.
INCHES		25.32	33.18	33.18	33.18
MM		643.03	642.74	642.74	642.74
AC-FT		107.	140.	140.	140.
THOUS CU M		132.	172.	172.	172.

SURFACE AREA=	0.	6.	9.	18.	19.	25.
CAPACITY=	0.	53.	113.	245.	430.	649.
ELEVATION=	695.	722.	730.	740.	750.	760.

SUMMARY OF DAM SAFETY ANALYSIS

PMF

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	722.00	722.00	724.00
STORAGE	53.	53.	66.
OUTFLOW	0.	0.	19.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.14	723.96	0.00	65.	17.	0.00	18.17	0.00
.15	724.03	.03	66.	20.	1.67	18.00	0.00
.50	724.91	.91	[illegible]	549.	7.25	15.67	0.00
1.00	725.27	1.27	74.	1142.	10.17	15.67	0.00

SUMMARY OF DAM SAFETY ANALYSIS

100-YEAR FLOOD

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	722.00	722.00	724.00
STORAGE	53.	53.	66.
OUTFLOW	0.	0.	19.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	723.98	0.00	66.	17.	0.00	13.75	0.00

END

DATE

FILMED

12-81

DTIC